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15. Supplementary Notes

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16. Abstract (MAXIMUM 200 WORDS)

This report provides an evaluation of the fire fighting capabilities of water mist fire suppression systems in large (~3000 m^3) machinery spaces. The primary objective of this investigation was to evaluate the applicability of the International Maritime Organization test protocol to larger, Class 3 machinery spaces (>3000 m^3).

Four generic water mist systems produced using off-the-shelf industrial spray nozzles were included in this evaluation. The capabilities of both total protection and zoned total protection systems were identified during this investigation. The zoned systems demonstrated the same extinguishment capabilities as the total protection systems. The systems were evaluated against a series of heptane spray and pan fires ranging in size from 2.5 – 10.0 MW. The fires were located under a 1.0 m horizontal obstruction plate adjacent to a bulkhead similar to the fires conducted in MSC Circular 668.

The capabilities observed for the water mist systems (both zoned and total flooding) in the 3000 m^3 machinery space followed the same trends found throughout literature on water mist. The steady-state extinguishment model developed during previous phases with this investigation showed reasonably good agreement with the results of these tests. The strengths and weaknesses of the IMO test protocol were also identified. The conservative nature of the protocol (due to the high ventilation rates and smaller fire sizes (i.e., 1.0 MW)) will limit the use of water mist in larger machinery spaces. Based on this analysis, it was concluded that it is highly unlikely that any system discharging only water will ever successfully complete the protocol for volumes greater than 2000 m^3.

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EXECUTIVE SUMMARY

In December 1994, the International Maritime Organization (IMO) approved guidelines for alternative arrangements for halon fire extinguishing systems. Since the development of these guidelines, numerous research programs have demonstrated that, if properly designed and tested, water mist fire suppression systems can provide effective protection of Category A machinery spaces with volumes up to 500 m^3. The conclusions developed during these previous investigations also suggest that water mist systems may be inappropriate for larger machinery spaces due to the need for some degree of oxygen depletion to aid in the extinguishment of obstructed fires. To validate these conclusions, a series of full-scale fire suppression tests were conducted to evaluate the capabilities and limitations of water mist systems in large machinery spaces (~3000 m^3).

Four generic water mist systems, produced using off-the-shelf industrial spray nozzles, were included in this evaluation. The capabilities of both total protection and zoned total protection systems were identified during this investigation. Surprisingly, the zoned systems demonstrated the same extinguishment capabilities as the total protection systems. The systems were evaluated against a series of heptane spray and pan fires ranging in size from 2.5 – 10.0 MW. The fires were located under a 1.0 m horizontal obstruction plate adjacent to a bulkhead similar to the fires required by MSC Circular 668, “Interim Test Method for Fire Testing Equivalent Water-Based Fire-Extinguishing Systems for Machinery Spaces of Category A and Cargo Pump-Rooms (IMO, 1996b).” The fires were conducted at two elevations in both ventilated (the doors to the space were left open) and unventilated (closed compartment) machinery spaces.

The capabilities observed for the water mist systems (both zoned and total flooding) in the 3000 m^3 machinery space followed the same trends found throughout literature on water mist. Small fires must be extinguished by direct flame interaction with the mist, while the obstructed fires are extinguished primarily by oxygen depletion (indirect effects). Fires that are extinguished by direct flame interaction are typically extinguished in less than one minute and are relatively unaffected by compartment volume or ventilation conditions. Fires that require some degree of oxygen depletion to aid in extinguishment (obstructed fires) have longer extinguishment times which have been shown to be a function of fire size to compartment volume ratio (assuming a constant ventilation condition). The extinguishment times for these fires approach infinity as the size of the fire is reduced to the critical value. This critical value/size is primarily a function of the ventilation conditions in the space. These obstructed fires serve as the limiting case.

The steady-state extinguishment model developed during previous phases with this investigation was further validated using the results of these tests. The model assumes that obstructed fires are extinguished through a reduction in oxygen concentration resulting from both the consumption of oxygen by the fire and dilution of the oxygen with water vapor. The predictions made by the model showed reasonably good agreement with the results of these tests. Variations between predicted and measured results were attributed to the lack of a well-mixed environment in the space during extinguishment, which is one of the primary assumptions used by the model.

The strengths and weaknesses of the IMO test protocol were also identified. As currently written, the protocol ensures that water mist systems are designed with the proper nozzle spacing and spray characteristics to have a high probability of extinguishing a wide range of fire sizes in machinery spaces with varying degrees of ventilation. The protocol also ensures that the discharge rate is adequate to provide the required thermal management needed to minimize the damage for the longer extinguishment times that are characteristic of water mist systems for smaller obstructed fires. The conservative nature of the protocol (due to the high ventilation rates and smaller fire sizes (i.e., 1.0 MW)) will limit the use of water mist in larger machinery spaces. Based on this analysis, it was concluded that it is highly unlikely that any system discharging only water will ever successfully complete the protocol for volumes greater than 2000 m^3.

Recommendations were made for improving the IMO test protocol which should broaden the range of machinery space volumes in which water mist systems can be installed. These recommendations include selecting a more representative ventilation condition during testing and scaling the size of the test fires as a function of the volume of the machinery space.